BEST AVAILABLE COPY

D7

Consumer and Corporate Affairs Canada	Consommation et Corporations Canada

(11) (A) No. 1 168 283

(45) ISSUED 840529

(52) CLASS 309-6

(51) INT. CL. ^{3} H05B 3/03,3/46

(19) (CA) **CANADIAN PATENT** (12)

(54) ELECTRODE DEVICE FOR ELECTRICALLY HEATING UNDERGROUND DEPOSITS OF HYDROCARBONS

(72) Inoue, Takeo;
Teratani, Hiroshi;
Kobayashi, Toshiyuki,
Japan

(73) Granted to Mitsubishi Denki Kabushiki Kaisha
Japan

(21) APPLICATION No. 375,295

(22) FILED 810413

(30) PRIORITY DATE Japan (51153/80) 800414
Japan (51173/80) 800414
Japan (51174/80) 800414

NO. OF CLAIMS 11

Canada

DISTRIBUTED BY THE PATENT OFFICE, OTTAWA.

FIG. 1 (PRIOR ART)

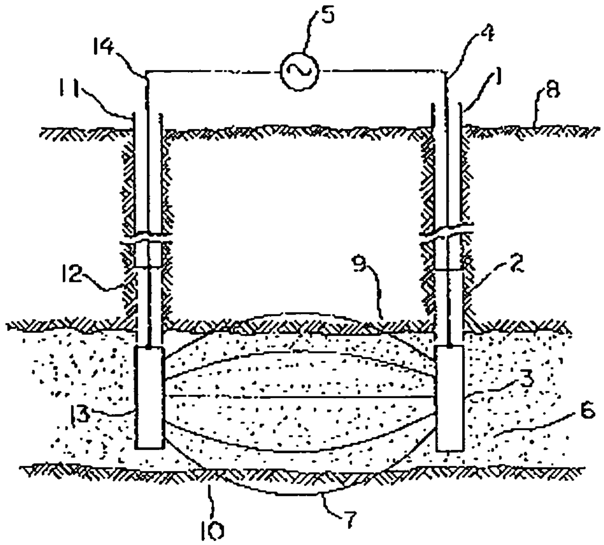
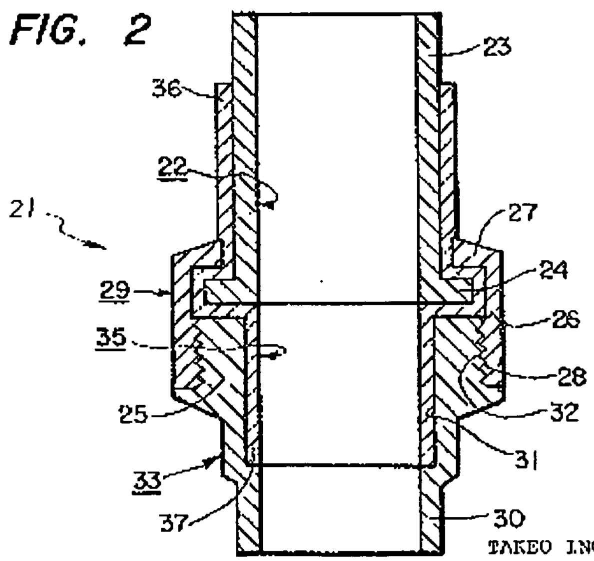


FIG. 2



TAKEO INOUE
HIROSHI TERATANI
TOSHIYUKI KOBAYASHI
Inventors
Riches McKenzie & Herbert
Attorney

1168283

3-2

FIG. 3

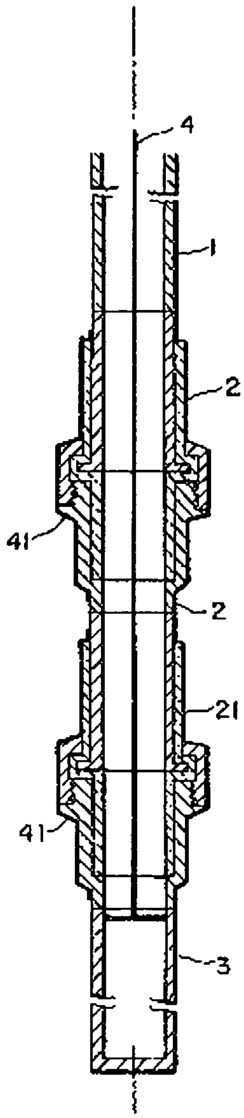


FIG. 4

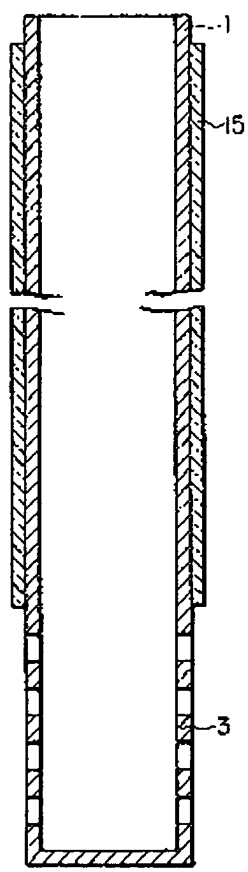
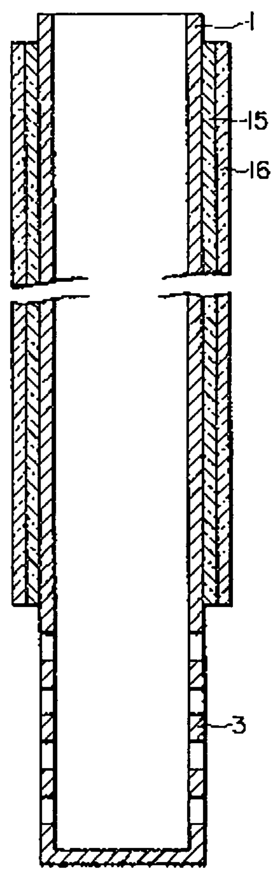


FIG. 5



TAKEO INOUE
HIROSHI TERATANI
TOSHIYUKI KOBAYASHI
Inventors

Richer McKenzie & Herbert
Attorney

FIG. 6

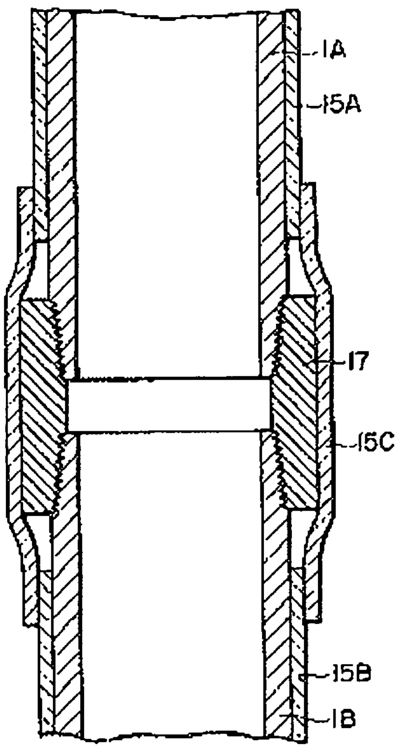
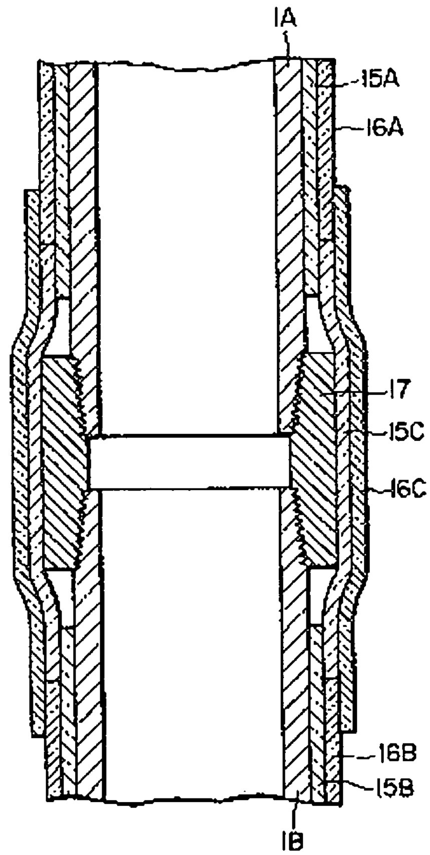


FIG. 7



TAKEO INOUE
HIROSHI TERATANI
TOSHIYUKI KOBAYASHI
Inventors

Richard McKenzie & Gilbert
Attorney

M14-25429M/KH/81

ABSTRACT OF THE DISCLOSURE

An electrode device for electrically heating underground deposits of hydrocarbons such as oil sand or oil shale. Plural well pipe sections are joined through insulated pipe joints with an electrode connected through one of the insulated pipe joints to a lower one of the pipe sections. Each of the insulated pipe joints includes a first tubular member having a flange portion at one end thereof, a second tubular member having a cap portion at one end which is received in the flange portion of the first tubular member with a gap therebetween, and an insulating member disposed in the gap for hermetically coupling the first and second tubular members and for electrically insulating first and second tubular members from one another.

ELECTRODE DEVICE FOR ELECTRICALLY HEATING UNDERGROUND DEPOSITS OF HYDROCARBONS

BACKGROUND OF THE INVENTION

The present invention relates to an electric device used to electrically heat underground deposits of hydrocarbons. More specifically, the present invention relates to an electrode device which is used to supply electrical power to an underground deposit thereby to heat the hydrocarbons present in the deposit to cause them to have a lower viscosity and higher fluidity in order to more easily remove them from the well.

The term "hydrocarbons" as used hereinafter means petroleum or oil, bitumen contained in oil sand (also called "tar sand") and kerogen contained in oil shale. These will all be referred to as "oil" for simplicity.

If the oil in the underground deposit has sufficient fluidity, it is possible to extract the oil through the well either by gas pressure coexisting in the oil layer or by forcing a liquid such as brine into one well to force the oil to flow out of another well. However, should the underground oil have low fluidity, it cannot be extracted until the oil is made more fluid. A general method of making the oil fluid is to heat the oil thereby to lower the viscosity of the oil. The temperature suitable for this is different for different types of oil.

There have been proposed as oil layer heating methods

the injection of hot water or water vapors at a high temperature under a high pressure, supplying electrical power to the underground deposit, underground combustion in which the underground oil layer is ignited with a supply of air so that it may be burned, and the use of explosives. The last two methods are difficult to control so that they are not in general use.

According to the method of injecting the hot water or water vapor at a high temperature and under a high pressure, the oil layer is heated to enhance the fluidity of the oil to cause the fluid oil to flow out to the ground surface. If, however, some regions of the oil deposit have a low resistance to the flow of hot water or water vapors or there are voids in the oil layer, the water or vapors may collect in these regions and fail to diffuse throughout the whole layer. Moreover, if the oil layer is solid and dense, the hot water or its vapors will again not diffuse so that the oil layer cannot be heated.

Heating by the supply of electrical power is performed by drilling a plurality of wells in the oil layer and by establishing potential differences between electrodes disposed in the wells so that the oil layer is heated by its resistance to the electrical current which flows therethrough. This technique is advantageous in that the oil layer can be wholly heated with ease even if it has voids or is solid and dense. However, another device is required for pumping up the fluid oil.

For improving the oil producing efficiency, there has

further been proposed a method which includes a first step of heating the oil layer by electrical resistance heating and a step of injecting hot water or water vapors at a high temperature and under a high pressure when the oil layer becomes soft while continuing the heating so that the resultant fluid oil may be pumped out. In order to efficiently heat the oil layer, the electrode device must be sufficiently electrically insulated that the leakage of electrically current into underground portions other than the oil layer is avoided as much as possible. The electrode device is also required to be unbreakable with respect to the underground soil pressure, the pressure of the vapors which are generated by the heating operation, and the pressure of injected hot water or hot high pressure water vapors. The electrode device is further required to be free from leakage of hot water or hot high pressure water vapors.

In order to explain, the electrode device of this general type more fully, an example in which the oil is extracted from oil sand will be described.

Oil sand, also called "tar sand", is present in large quantities in Canada, Venezuela and the United States. The oil in the oil sand is typically mixed with brine between sands in deposits. Moreover, it typically has such a remarkably high viscosity that it has essentially no fluidity in its natural state. A deposit of the oil sand may be partially exposed in a valley or at the banks of

a river but is most often located entirely underground at a depth of 200 to 500 m while having a thickness of several tens of meters. Due to consideration of economy and environmental protection, it is necessary to separate out the oil underground and to extract only the oil from the well. Moreover, since the extraction of oil from a shallow underground layer is accompanied by a danger of subsidence, it is desirable to extract oil only from underground layers lying deeper than 300 m.

Further aspects of the background of the invention and the invention of the present application are described with the assistance of the accompanying drawings in which:

Fig. 1 is a schematic sectional view showing a conventional prior art installation of the general type with which the invention is utilized;

Fig. 2 is a cross-sectional view of an insulated pipe joint of the invention;

Fig. 3 is a cross-sectional view showing several joined pipe sections, an electrode and insulated pipe joints in accordance with the invention; and

Figs. 4-7 are a series of cross-sectional views illustrating the use of insulating coatings in accordance with the invention.

Fig. 1 illustrates the heating of an oil sand layer by electrodes coupled to a power supply. In Fig. 1, reference numerals 1 and 11 indicate main guide pipes made of steel, 2 and 12 indicate insulators joined to the main guide pipes 1 and 11, 3 and 13 indicate electrodes joined to the insulators 2 and 12, perforations are formed in the electrodes 3 and 13, and 4 and 14 indicate cables for feeding an electric current to the electrodes 3 and 13. This assembly is hereinafter called together the

"electrode device". Reference numeral 5 indicates a power source, 6 indicates an oil sand layer, 7 indicates an electric current flowing between the electrodes 3 and 13, 8 indicates the ground surface, 9 indicates an overburden layer, and 10 indicates a layer below the oil sand layer.

When a voltage is applied to the electrodes 3 and 13 which are buried in the oil sand layer 6 from the power source 5 through the cables 4 and 14, the current 7 flows in accordance with the electric resistance of the oil sand layer 6 as a result

of which the oil sand layer 6 is heated by Joule or resistance heating. Although, the current 7 partially flows into the over-burden layer 9 and the layer 10, the leakage is maintained at a low level because the insulators 2 and 12 are interposed between the main guide pipes 1 and 11 and the electrodes 3 and 13. After the oil sand layer 6 has been warmed, the power supply is interrupted. Hot water or water vapors at a high temperature under a high pressure are then forced from the upper inlet of one main guide pipe 1 of the electrode device and flow through the oil sand layer 6 until they come out of the other main guide pipe 11 carrying the oil. In order to improve the flow rates of the hot water or the hot pressure water vapors, perforations are formed in the electrodes 3 and 13.

Since the upper portions of the insulators 2 and 12 are connected to the main guide pipes 1 and 11 and the lower portions are connected with the electrodes 3 and 13, a downward tensile stress is always applied to the insulators. Moreover, since the assembly can be at a temperature as high as 250°C to 300°C, the insulators should be able to withstand such temperatures. Also, since the insulators 2 and 12 are buried underground as deep as several hundred meters with the electrodes 3 and 13 suspended from their lower ends with the upper ends thereof connected to the main guide pipes 2 and 12, the insulators 2 and 12 will almost certainly contact or collide with the well walls while they are lowered into the well. Because of the

great total weight, any slight contact will impose a high mechanical impact upon the insulators 2 and 12. Therefore, the insulators 2 and 12 are required to be able to withstand anticipated levels of mechanical impact.

In an electrode device which heats an oil sand layer when it is supplied with an electric current, a major problem is that the electric resistance in the oil sand layer is approximately equal to the overburden layer. Since these electric resistances differ depending on place and conditions, they cannot generally be precisely stated. However, average values are 100Ω-m for the oil sand layer and 100-150Ω-m for the overburden layer. As a result, if an electric current is supplied to two electrode devices which are constructed by connecting electrodes to guide pipes made of steel pipes and by disposing those electrodes in the oil sand layer, most of the current will be consumed in the overburden layer. In order to avoid this problem, it is necessary either to cover the surfaces of the guide pipes with an insulating coating or to insulate the electrodes from the guide pipes.

Various attempts have been made to provide insulators which satisfy the aforementioned requirements. In one such attempt, flanged tubular members made of metal are coated with an organic resin which provides a high resistance to heat. An appropriate material is polytetrafluoroethylene resin (for example "Teflon™" which is trade name of du Pont). With this construction, insulating members are provided which are satisfactory in their ability to withstand a suspending load

and mechanical impact forces. However, it has proved quite difficult to coat the flange portions satisfactory with the insulating material. Moreover, even if satisfactory insulating characteristics are provided at room temperature, the insulating coating has a tendency to separate, especially around the flange portions, due to repeated thermal expansion and contraction such as is typically encountered in normal operating conditions. If the insulation coating is broken or caused to flake off, the insulators thus produced become useless.

In a second attempt, porcelain material has been used for forming the insulators. However, it is also necessary in constructing the insulators to take into account the requirement for providing water and oil tight characteristics with respect to the connection between the main guide pipes 1 and 11 and the electrodes 3 and 13 as well as between the insulating member. The connection has generally been made by shrink fitting metal pipes on the outer peripheral surface of the porcelain pipe and then connected with other metal pipes ordinary techniques such as welding or attachment with bolts. With this construction, although the wall or oil tight characteristics may be acceptable at room temperature, the strength of the shrink-fitted joints tends to drop as the temperature is increased so that the ability to support the suspended load is correspondingly lowered. Moreover, breakage of the porcelain may taken place as a result of the stress imposed upon the leading end portions of the shrink-

fitted areas. In order to eliminate such drawbacks, there has been proposed the use of a porcelain pipe having ends formed as flange portions with the flange portions fastened to metal pipes with packings interposed between the contact surfaces. With this construction, the above-stated requirements are met at room temperature. However, the water and oil tight sealing tends to deteriorate upon repeated thermal expansion and contraction. Moreover, porcelain intrinsically lacks strength against mechanical impact forces. Thus, it has a high tendency to be broken by a mechanical impact force such as is ordinarily encountered while the assembly is lowered through the well. Thus, the provision of a porcelain insulator suffers from the unavoidable defect that there is a high tendency of breakage.

Yet further, insulators formed of organic polymeric compounds have been proposed. Although such compounds may have a high strength at room temperature and are quite good electrical insulators, most of the compounds of this general class are not particularly heat resistant. Specifically, very few compounds of this type are known which are resistant to hot water or water vapor at high temperature and under high pressure.

SUMMARY OF THE INVENTION

In accordance with the invention, there is provided an electrode device for electrically heating underground deposits of hydrocarbons including a plurality of well pipe sections, an electrode adapted to be disposed in an underground deposit of hydrocarbons for supplying an electric current to the underground deposits, a plurality of insulating pipe joints each including a first tubular member having a flange portion at one end thereof, a second tubular member having a cap portion at one end thereof adapted to be received in the flange portion of the first tubular member with a gap therebetween and an insulating member disposed in the gap between the flange portion and the cap portion for hermetically coupling the first and second tubular members while electrically insulating them from one another and with the insulating pipe joints being used to couple at least some of the pipe sections together and the electrode to one of the pipe sections, and a cable connected to the electrode for supplying an electric current thereto.

At least some of the insulating pipe joints can be interconnected. The insulating member of each of the insulated pipe joints includes a first insulating portion disposed in the gap between the flange portion in the cap portion and second insulating portions disposed adjacent inner and outer surfaces of the tubular members with the first and second insulating portions being formed integrally with each other. Preferably, the

insulating member of each of the insulated pipe joints is made of a glass-mica molding formed from powders of glass and mica. An insulating coating may be provided on at least a portion of the outer surface of the insulated pipe joints. This coating may be a resin of polytetrafluoroethylene, a resin of diphenyl oxide. Moreover, a protective layer of insulation can be provided around at least a portion of the insulating coating. The protective layer may be an inexpensive material such as polyethylene, polypropylene or polyvinyl chloride.

Further objects and advantages of the invention will appear from the following description taken together with the accompanied drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In accordance with the invention, there is provided an electrical heating electrode device which is entirely free of the above-mentioned drawbacks. A preferred embodiment of the electrode device of the invention will be described in detail, first with reference to Fig. 2 which shows a cross-sectional view of an insulated pipe joint 21 which is utilized with the electrode device of the invention.

The pipe joint generally designated 21 in Figure 2 comprises four basic elements:

a first tubular member 22, a second tubular member 33, a cylindrical sleeve-like cover member 29, and an insulating member 35.

The first tubular member 22 comprises a cylindrical tubular portion 23 with a radially outwardly extending flange portion 24 at a lower end as shown.

The second tubular member 33 comprises a cylindrical tubular portion 30 with a radially outwardly extending hub portion

25 at an upper end as shown. The interior diameter of tubular portion 30 of the second tubular member 33 is shown identical to the interior diameter of tubular portion 23 of the first tubular member 22.

Hub portion 25 of the 2nd tubular member 33 is provided with an internal annular recess 31 as shown. Hub portion 25 is also provided with external threads 32 which mate with threads 28 on cover member 29 to be described.

Sleeve-like cover member 29 comprises a cylindrical, tubular, drum-like portion 26 with internal threads 28 at one lower end as shown in Figure 2 and a radially inwardly extending cap portion 27 at the other upper end. As shown, tubular portion 26 has a larger internal diameter that the external diameter of flange portion 24 of the first tubular member 22 so as to provide a gap therebetween to be occupied by insulating member 35. Cap portion 27 of cover member 29 has an internal diameter larger than the external diameter of tubular portion 23 of the first tubular member 22 so as to form a gap therebetween. The internal diameter of cap portion 27 is smaller than the external diameter of flange portion 24 of the first tubular member 22.

Preferably the first tubular member 22, second tubular member 33 and cover member 29 are made from steel.

Insulating member 35 includes an outer circumferentially insulating portion 36 which surrounds external surfaces of tubular portion 23 of first tubular member 22 and an inner circumferentially insulating portion 37 which fits inside the internal annular recess 31 of hub portion 25 of the second tubular member 33. The inner insulating portion 37 has the same internal diameter as that of tubular portion 30 of the second tubular member 33. As may be seen, insulating member 35 comprises an integral

member extending from portion 36 thereof to portion 37 thereof. Integral insulating member 35 thus spaces surfaces of the first tubular member 22 from surfaces of second tubular member 33 and cover member 29 by a gap occupied as seen in Figure 2 by insulating member 35. Insulating member 35 insulates first tubular member 22 from contact with second tubular member 33 and cover member 29.

With cover member 29 screwed down onto second tubular member 33 as shown in Figure 2, flange portion 24 of first tubular member as encased by insulating member 35 is sandwiched between cover member 29 and the upper end of hub portion 25 of the second tubular member 33, whereby insulating member 35 may form a hermatic seal between first tubular member 22 and second tubular member 33.

By screwing cover member 29 onto second tubular member 33, first tubular member 22 may be firmly, sealably coupled to second tubular member 33 yet insulatively isolated therefrom.

In assembly, first tubular portion 22 may be inserted through cover member 29 following which cover member 29 may be screwed onto second tubular portion 33. The insulating member 35 may be seen to occupy a gap between the first tubular member 22 and the combination of the second tubular member 33 and cover member 29.

Preferably, the entire insulating member is made of a composition of glass and mica and is formed by a molding process. The insulating member is formed by heating a mixture of powders of glass and mica to a sufficiently high temperature that the mixture becomes fluid. Once the mixture is fluid, it is pressure molded using a mold of appropriate shape. The formation of the insulating member 35 will be descirbed in more detail.

The first tubular member 22 and the second tubular member 33 are assembled to be positioned as shown in Fig. 2 and are then heated to a predetermined temperature. The two tubular members at the elevated temperature are fitted into a mold. Next, a mixture of glass and mica powders is prepared by pre-molding the mixture into the form of a preliminary molded member of a cylindrical shape which will fit in the gap between the tubular portion 23 of the first tubular member 22 and cover member 29. The preliminary molded member is heated to a predetermined temperature and fitted in the gap in a heated condition. Next, a pressure is applied to the preliminary molded member before it cools to force the material of the member to flow into the gap between the first and second tubular members and into the internal annular recess 31 in the second tubular member 33.

For the material of the preliminary molded member, 45 wt% of glass powder prepared by pulverizing a glaze used for enamel coating steel objects, commercially available as Product No. 2312 of Nippon Ferro, Ltd., to a size of 200 mesh mixed with 55 wt% of mica powder of synthetic phlogopoite of a size of 60 to 200 mesh. 5 wt% of water is added to the resultant mixture to wet it so it can be molded. 1500 gm of the wetted mixture is molded using a cold pressure molding process to form a cylindrically shaped body using a mold (not shown). The preliminary molded member was disposed in a drier at 120°C for two hours to dry it prior to its use in forming the insulating member 35.

As described above, the cover member 29 and the hub portion 25 are joined by screw threads. However, the invention is not limited thereto as the cover member 29 and the hub portion 25 can be joined by welding.

In an alternate embodiment, the cap portion 27 of

the cover member 29 is divided into four quadrants two of which are removed. The flange portion 24 of the first tubular member 22 is then cut such that the remaining part of the flange portion 24 can fit through the two removed quadrants of the cap portion 27 so that the flange portion 24 can be located under the cap portion 27 of the cover member 29.

With the insulated pipe joint described above, a tensile force imposed on the ends of the joint is converted into a compressive force which acts between the cap portion 27 and flange portion 24. Since the compression strength of the insulating member 35 of the type described is much greater than its tensile strength and since the force per unit area can be suitably set by adjusting the extent of the area on which the compressive forces are applied, the resulting assembly is quite strong and able to withstand high tensile forces imposed on the ends of the joint.

At high temperatures, for instance 300°C, the heat resistant characteristics of the insulating member are primarily determined by the thermal characteristics of the glass material used as the starting material. Particularly, the transition temperature of this material is important. If the transition

temperature is, for instance, in a range of 550 °C to 600 °C, a high mechanical strength for the overall assembly will be preserved to a temperature of at least 300°C.

With respect to the resistance to mechanical impact forces, the mica powder which is used to form the insulating member is composed of particles having a flat shape wherein the ratio of the diameter to the thickness of a single scale particle is generally in a range of 30 to 50:1. Due to the presence of the scale particles, the molded insulating member has a laminated form thereby providing it with a high elasticity. This high elasticity would not be present if the insulating member were formed only of glass powders. Due to the laminated construction, the insulating member is provided with a much greater resistance to repeated temperature changes and mechanical impact forces then is a prior art type of insulating member made of an inorganic compound. Therefore, the insulating member produced in accordance with the invention is sufficiently strong that it can withstand the typical impact forces which are encountered during the use of the structure.

Next, the construction of a preferred embodiment of an electrode device of the invention utilizing the above-described insulated pipe joint 21 will be given with reference to Fig. 3. Reference numerals 1 to 4 used in Fig. 3 indicate similar components as those of Fig. 1. The righthand half of Fig. 3 shows the completed structure of the insulated pipe joint

21. As shown in the figure, the insulating member 2 includes two insulated pipe joints 21. One end of the insulating member 2 is connected to the pipe 1 and the other to the electrode 3. These connections may be made by well-known techniques such as welding or by the use of screw threads.

As, in accordance with the invention, the completed insulated pipe joint 21 has a common throughhole of constant internal diameter, the assembly and use thereof is quite easy. For instance, the provision of the above-described partitions is quite simple. Of course, more than two insulated pipe joints 21 can be provided as needed. Also, one of the pipe joints 21 can be connected directly to the pipe 1.

If needed, such as in the case brine having a high salt concentration is used, the outer surface of the insulated pipe joint 21 can be covered with a coating 41 of an organic substance having a sufficiently high heat resistant property. This is shown in the lefthand part of Fig. 3. For example, the coating 41 can be formed by shrink fitting a "Teflon™" tube.

As described above, in accordance with the invention, the pipes and the electrodes are connected through the insulated pipe joints. Tensile forces applied at the ends of the insulated pipe joints are converted into compression forces which act between the cap portions and the flange portions thereof. Since the compression strength of the insulating member is much greater than the tensile strength thereof, the overall electrode device

of the invention has a quite high mechanical strength and can withstand high pressures and strong mechanical impact forces so that it can be used under severe operating conditions often encountered in oil well application.

Yet further, the coating 41 and the insulating members 2 and 12 of the electrode can be formed from other materials. To determine what materials are best for these members, tests were conducted to investigate the resistance of various organic polymeric compounds to hot water and water vapor at high temperature and under high pressure. The compounds investigated are listed in Table 1 herein.

Regarding the tests, test pieces of each of the materials were placed in quartz test tubes filled with pure water. These test tubes were placed in a 2-liter autoclave containing pure water. The autoclave was held at 280°C at an internal pressure of 68 kg/cm^2 for a period of 10 days. The autoclave was then cooled to a room temperature and the test pieces were checked for appearance. The results are presented in Table 2 from which it can be seen that hot water and steam had a much more adverse affect than dry heat. Of the materials tested, only polytetrafluoroethylene resin and diphenyl oxide resin were acceptable.

A coating of water and steam resistant resin can be formed around the pipe 1 by repeatedly applying coatings of the material and baking the assembly until the desired thickness is

obtained. Also, a coating of the heat resistant reisn can be formed by first preparing a tube of the resin having an inside diameter slightly larger than the outside diameter of the pipe 1 and then slipping the tube over the pipe 1. If the resin is in the form of a sheet or tape, it may be wound directly around the pipe 1 and then fusion-bonded if necessary. As described above, a heat-shrinkable tube of polytetrafluoroethylene can be slipped over the pipe 1 and heated to fit it tightly to the pipe.

As discussed above, when the assembly including the electrode is inserted into the oil well, there is unavoidable contact with the inner wall of the well so that the heat resistant insulating coating may be damaged. To prevent this, protective coating of insulation 16 may be formed around the insulation 15 as shown in Fig. 5. Since the protective coating of insulation 16 may melt or collapse if the electrode is exposed to high temperatures, it can be made of an inexpensive material such as polyethylene, polypropylene or polyvinyl chloride.

Typically, the total length of the guide pipe 1 is 200 to 500 m. However, a single section of the steel pipe that makes up the fuide pipe 1 is only about 10 m in length. To join the pipe sections, each pipe section is provided with a taper thread on one end and the pipe sections are joined by screwing them together. An insulating coating must also be formed around the joined parts of the pipe sections and on the surface of the coupling. To accomplish this, as shown in Fig. 6, steel pipes

1A and 1B are covered with the coating of heat resistant insulating material 15A and 15B and are joined by a coupling 17. A coating of heat resistant insulation 15C is formed around the coupling extending into adjacent areas. A heat-shrinkable tube of a polytetrafluoroethylene is particularly suitable in this case.

To protect the insulating coatings from direct contact with the inner wall of the well, steel pipe sections 1A and 1B covered with the coating of heat resistant insulating material 15A and 15B and protective coatings of insulation 16A and 16B are first joined through the coupling 17. Thereafter, the coupling 16 is coated with the heat resistant insulation 15C and then a layer of 16C if formed around the coupling and in the adjacent areas as shown in Fig. 7.

1A and 1B are covered with the coating of heat resistant insulating material 15A and 15B and are joined by a coupling 17. A coating of heat resistant insulation 15C is formed around the coupling extending into adjacent areas. A heat-shrinkable tube of a polytetrafluoroethylene is particularly suitable in this case.

To protect the insulating coatings from direct contact with the inner wall of the well, steel pipe sections 1A and 1B covered with the coating of heat resistant insulating material 15A and 15B and protective coatings of insulation 16A and 16B are first joined through the coupling 17. Thereafter, the coupling 16 is coated with the heat resistant insulation 15C and then a layer of 16C if formed around the coupling and in the adjacent areas as shown in Fig. 7.

Table 1

Sample	Chemical name (abbr.)	Manufacturer	Item No.	Form	Thickness	Method of sample preparation
A	Polytetrafluoroethylene resin (PTFE)	Nitto Electric Industrial Co., Ltd.	No.900	Tape	0.1	Cutting
B	Tetrafluoroethylene-hexafluoropropylene copolymer resin (FEP)	"	No.945	Tape	0.125	"
C	Tetrafluoroethylene-perfluoroalkylvinyl ether copolymer resin (PFA)	"	No.460	Tape	0.125	"
D	Polyimide resin	Toray Industries, Inc.	Kapton	Film	0.05	"
E1	Diphenyl oxide resin	Ryoden Chemical Industries Co., Ltd.	V505-50	Liquid	0.05	Baking after application to tinplate
E2	" + mica powder (20 wt%)					
F	Diphenyl oxide resin - laminated with glass cloth	"	PGD-637	Sheet	2 mm	Cutting

Sample	Chemical name (abbr.)	Manufacturer	Item No.	Form	Thickness	Method of sample preparation
G	Silicone resin	Shinetsu Chemical Industry Co., Ltd.	KR-280	Liquid	0.05	Baking after application to tinplate
H	Silicone resin-laminated with glass cloth	Nikko Kagaku K.K.	NL-SG-13	Sheet	3 mm	Cutting
I	Epoxy resin-laminated with glass cloth	"	NL-EG-23	Sheet	3 mm	Cutting
J	Unsaturated polyester resin-laminated with glass cloth	"	NL-PoGX	Sheet	3 mm	Cutting

Table 2

Sample	Appearance
A	OK.
B	Turned into a lump.
C	Do.
D	Collapsed
E1	OK.
E2	Do.
F	Do.
G	Turned into a lump.
H	Glass whitened (Resin came apart)
I	Do.
J	Do.

WHAT IS CLAIMED IS:

1. An electrode device for electrically heating underground deposits of hydrocarbons comprising: a plurality of well pipe sections; an electrode adapted to be disposed in an underground deposit of hydrocarbons for supplying an electric current to said underground deposit; a plurality of insulated pipe joints each including a first tubular member having a flange portion at one end thereof, a second tubular member having a cap portion at one end thereof adapted to be received in said flange portion of said first tubular member with a gap therebetween, and an insulating member disposed in said gap between said flange portion and said cap portion for hermetically coupling said first and second tubular member and for electrically insulating said first and second tubular members from one another, said insulated pipe joints being operatively disposed to couple at least some of said pipe sections and said electrode while electrically insulating said at least some of said pipe sections and said electrode; and a cable connected to said electrode for supplying an electric current to said electrode.

2. The electrode device as set forth in claim 1 wherein at least some of said insulated pipe joints are interconnected.

3. The electrode device as set forth in claim 1 wherein said insulating member of each of said insulated pipe joints comprises a first insulating portion disposed in said gap between said flange portion and said cap portion, and second insulating

portions disposed adjacent inner and outer surfaces of said tubular members, said first and second insulating portions being formed integrally with each other.

4. The electrode device as set forth in claim 1 wherein said insulating member of each of said insulated pipe joints is made of a glass-mica molding formed from glass and mica powders.

5. The electrode device as set forth in claim 1 further comprising an insulating coating profided on at least a portion of an outer surface of said insulated pipe joints.

6. The electrode device as set forth in claim 5 wherein said insulating coating is polytetrafluoroethylene.

7. The electrode device as set forth in claim 6 wherein said insulating coating comprises a resin of thermally shrinkable polytetrafluoroethylene.

8. The electrode device as set forth in claim 5 wherein said insulating coating comprises a resin of diphenyl oxide.

9. The electrode device as set forth in any of claims 5-7 further comprising a protective layer of insulation upon at least a portion of said insulating coating.

10. the electrode device as set forth in any of claims 5-7 further comprising a protective layer of insulation upon at least a portion of said insulating coating, said layer of protective insulation comprising a material selected from the group consisting of polyethylene, polypropylene and polyvinyl chloride.

11. An electrode device for electrically heating underground deposits of hydrocarbons comprising a plurality of interconnected well pipe sections, an electrode adapted to be disposed in an underground deposit of hydrocarbons supplying electric current to said underground deposit, at least one insulated pipe joint including a first tubular member comprised of a well pipe section having a flange portion at one end thereof, a second tubular member comprised of said electrode disposed in alignment with said first tubular member, a cover member carried by said second tubular member having a cap portion at one end thereof disposed in overlying relation to said flange portion above said first tubular member with a gap therebetween, an insulating member disposed in said gap between said flange portion and said cap portion for hermetically coupling said first and second tubular member and for electrically insulating said first and second tubular members from one another, cable means connected to said electrode for supplying an electric current to said electrode and an insulating coating provided on at least an outer surface of said insulating pipe joint.